CORRELATION OF SOME CARBONIFEROUS SECTIONS IN NEW SOUTH WALES.

WITH SPECIAL REFERENCE TO CHANGES IN FACIES.

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(Plates iv–v.)

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Introduction.

This paper may be regarded as a sequel to that by Carey and Browne (1938) which deals with the stratigraphy, tectonics and palaeogeography of the Carboniferous rocks of New South Wales and Queensland. It takes into account the writer's investigations in the North Coast district of New South Wales, particularly those which were made since the publication of the work referred to above. A short discussion of the important Carboniferous sections in New South Wales is given and the transition from sequences which are partly terrestrial and partly marine to the wholly marine sequence of Rockhampton, Queensland, is noted (see Plate iv).

The changes in facies as shown by the character of the sediments are then dealt with and, finally, possible palaeogeographical conditions are considered.

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Previous Literature.

The Carboniferous Period in eastern Australia was discussed briefly and a comprehensive list of related literature was given by Sussmilch (1935). Carey and Browne (1938) followed this with a review of Carboniferous stratigraphy, tectonics and palaeogeography. The writer has referred to Carboniferous rocks on the North Coast of New South Wales in a series of papers (Voisey, 1934, pp. 336–338; 1936*a*, pp. 185–189; 1936*b*, pp. 157–158; 1938, pp. 454–458; 1939*a*, pp. 246–247; 1939*b*, pp. 260–261; 1939*c*, pp. 387–388; 1939*d*, pp. 399–401; 1940, pp. 193–209).

In addition to the above, reference is made to the work of others, particularly Sussmilch and David (1919), Browne (1926) and Osborne (1921, 1922, 1926, 1938) in the Hunter Valley, and Carey (1937) in the Werrie Basin.

Nomenclature.

The nomenclature adopted is that set out by Carey and Browne (1938, p. 602) except that the name Kullatine Series is used instead of Upper Kuttung Series for equivalent beds north of the Manning River Fault System (Voisey, 1939*a*).

As pointed out by Carey and Browne (1938), the names Kuttung and Burindi have always referred to terrestrial and marine beds respectively. The marine equivalents of the Upper Kuttung Series in the Drake area have been called the Emu Creek Series (Voisey, 1936*b*). The constituent rocks there are very different lithologically from those in the Macleay, Manning and Hunter districts to the south.

Now, in the Manning district, there are glacial beds corresponding to those of the terrestrial Upper Kuttung Series in the south but containing marine fossils. Therefore, in order to avoid violating the principle that Kuttung refers to the terrestrial series only, it is suggested that the name of Kullatine Series (Voisey, 1934) be retained for the equivalents of the Upper Kuttung Series in the Manning–Macleay area.

Discussion of Sections.

Hunter Valley.

The Hunter Valley section (Plate iv) is based on the work of Osborne (1922). It is generally regarded as the type-section for the Carboniferous System in New South Wales.

Osborne's later work, together with Browne's mapping of Gosforth (1926), demonstrates the fact that between Scone and the Coast there is much variation within the terrestrial Lower and Upper Kuttung sequences.

Werrie Basin.

Carey (1937, pp. 355–359) discusses the generalized section (Plate iv). He notes the importance of the oolitic limestone as a marker horizon in the Lower Burindi Series and records the presence of *Protocanites lyoni* near the base of that series. The Lower Kuttung beds are compared with those of the Hunter Valley. The presence of the marine *Amygdalophyllum-Lithostrotion* limestone horizon in the midst of a terrestrial sequence is important.

A coarse conglomerate at the base of the Upper Kuttung Series was traced by Carey for 50 miles. He compares it with the conglomerate at the base of the Glacial Stage in the Hunter Valley. He divides the series into three stages, viz., the Lower Glacial Beds, the Interglacial Beds and the Upper Glacial Beds. The Interglacial Stage consists of *Rhacopteris*-bearing strata, varves and tillites being developed in the two glacial stages.

Gloucester.

The Lower Burindi strata occurring on the limbs of the Gloucester Trough to the north are similar to those near Dungog and Clarencetown.

No big development of conglomerate corresponding to that at Wallarobba has been seen, so that a lava flow has been taken as the base of the Upper Burindi Series (Voisey, 1940). The lithology of this series is somewhat similar to that of the Lower Kuttung Series in the south but the sequence appears to be wholly marine and a rich fossil fauna has been found.

The Upper Kuttung Series consists of conglomerate and mudstones with *Rhacopteris* overlain by keratophyres and rhyolites associated with much pyroclastic material including some spectacular agglomerates and breccias. The volcanic suite was grouped by Sussmilch (1921) under the general name of Gloucester Rhyolites but there is more fragmental material than lava in most sections examined.

The change from terrestrial beds in the southern portion of the Gloucester Trough (see Osborne, 1938) to marine ones in the northern must take place between Weismantels and Stratford. It seems from the continuity of the structure that outcrops could be traced on the limbs of the Trough on each side of this axis though the country is rough and some of the field-work would be difficult.

The apparent absence of Upper Kuttung glacial beds in the sequences of the Gloucester Trough is most significant. It should be noted here that the laminated shales mentioned by Carey and Browne (1938, p. 598) are now believed to be in the Lower Burindi Series and are not likely to be glacial in origin.

Wingham–Mount George.

The Lower Burindi Series in this district does not seem to include any limestone. It passes upwards into the Upper Burindi Series and into the Kullatine Series without much change in lithology until the tillites are met. It has not been possible to divide what appears to be a continuous marine sequence into portions corresponding with the three series of the type-area. The marine origin of the tillites is proved by the presence in them of *Spirifer* at Kimbriki and Crinoid stems at Killawarra (Voisey, 1939*a*). (*Spirifer* sp. was found on a geology excursion in June, 1944.)

Taree.

The Lower Burindi Series retains its usual lithological characteristics in the neighbourhood of Taree. As at Barrington, thick beds of massive tuffs occur near the top of

the series, the base of the Upper Burindi being taken immediately above these. The useful *Lithostrotion* limestone horizon follows, associated with mudstones and tuffs.

The Kullatine Series is characterized by tuffs and tillites, the latter being found so low in the sequence that it is apparent that the *Rhacopteris*-bearing beds of the Main Clastic Zone are missing or have an insignificant development.

Kendall.

A comparatively small area of Carboniferous rocks is in a block, faulted upwards into the central region of the Lorne Triassic Basin between Heron's Creek and Ross Glen (Voisey, 1939*b*). A series of tuffs, mudstones, cherts, conglomerates and coal seams is developed. *Rhacopteris ovata* occurs in a chert band exposed in a cutting beside the old road opposite Kew Public School. A conglomerate which may mark the base of the Main Glacial Beds immediately overlies the horizon.

The occurrence of these terrestrial beds is most important as they do not appear to be represented at Taree less than thirty miles to the south.

Marine fossils have been found in road cuttings between Kew and Kendall evidently from beds stratigraphically below the *Rhacopteris* horizon.

Hastings Valley.

Poor outcrops have militated against the measurement of the sequence in the Hastings Valley, but essentially the same units as those met in the Yessabah–Wittitrin area (Voisey, 1936*a*) are represented. Typical Burindi sediments are to be seen in cuttings along the Oxley Highway on the Wauchope side of the Comboyne Road junction. Similar beds outcrop in the Cooperabung Mountains to the north. The lower portion of the Kullatine Series—the equivalent of the Main Clastic Zone is well developed between Telegraph Point and Rolland's Plains. The Main Glacial Beds appear at intervals between the Broken Bago Range and the Hastings River.

Macleay Valley.

The Lower Burindi Series is still characterized by grey and olive-green mudstones interbedded with a number of different kinds of tuff. Subordinate conglomerates and breccias occur. The most conspicuous rock is a crinoidal felspathic tuff. This must be present also in the Upper Burindi Series since it has not been possible to divide the Boonanghi Series (Voisey, 1934) (= Lower and Upper Burindi probably) into two parts.

The Kullatine Series of the Macleay and Hastings Valleys resembles the Upper Kuttung Series of the Hunter Valley type-area more closely than do equivalent beds in any of the intervening districts. It is characterized by a lower portion corresponding to Osborne's Main Clastic Zone and comprising tuffs and volcanic breccias with mudstones and cherts containing fossil wood and *Rhacopteris ovata* near the top. This is followed by the Main Glacial Beds with a conglomerate, probably fluvio-glacial at the base. The remainder of the sequence is made up of tillites and tuffs with subordinate varve-shales. The tillites are very similar lithologically to those in the Manning district in which marine fossils have been found, so it seems that they, too, are marine.

It is possible that many of the beds previously grouped to form the Kempsey Series (Voisey, 1934) belong to the Carboniferous suite but little further information than that previously recorded has been obtained.

Drake.

The Emu Creek Series, which resembles the Neerkol Series of Queensland, is probably the equivalent of the Upper Kuttung Series as forecast by Osborne (1921) and Reid (1930) and supported by Whitehouse (Voisey, 1936, p. 163). It is wholly marine and so far has not been found to include glacial beds. An important horizon is that containing *Productus pustulosus* and other forms, some of which are similar to those in the Upper Burindi Series of Gloucester. Neither the upper nor the lower limit of the series has been determined.

Rockhampton, Queensland.

In the Rockhampton district of Queensland the entire Carboniferous sequence is marine and is divided into the Rockhampton and Neerkol Series. The important *Lithostrotion* limestone horizon is present near the top of the Rockhampton Series.

Transition from Terrestrial to Marine Sequences.

A study of the Carboniferous rocks of eastern Australia reveals the following facts:

1. The Lower Burindi Series is always marine.
2. The Lower Kuttung Series of the Hunter Valley and Werrie Basin is terrestrial except for a horizon of marine beds in the Babbinboon area.
3. Between Weismantels and Stratford the terrestrial Lower Kuttung Series changes to the marine Upper Burindi Series but the lithology is very similar in both series.
4. Between Gloucester and Wingham there has been a change in lithology from the Kuttung to the Burindi type of sediment in the Upper Burindi Series.
5. No terrestrial Lower Kuttung rocks are known in the coastal area between the Manning River and Rockhampton (Queensland).
6. The main Clastic Zone of the Upper Kuttung varies in detail in the Hunter Valley and the Werrie Basin. It is present in the Gloucester Trough where it consists of much volcanic material; lavas, tuffs, breccias and agglomerates.
7. The Main Clastic Zone does not seem to be represented in the Manning Valley (excluding the area drained by its tributaries, the Gloucester and the Barrington). It reappears, however, at Kendall and is well developed in the Macleay Valley.
8. The Main Glacial Beds of the Upper Kuttung are well developed in the Hunter Valley and Werrie Basin areas, but are absent from the Gloucester Trough. In the Manning Valley some of the tillites, at least, are marine and the same may be true of corresponding beds in the Macleay Valley.
9. Probably the marine Emu Creek Series is synchronous with the Upper Kuttung Series.
10. In Queensland the change to a wholly marine sequence is complete, the two series being the Rockhampton and Neerkol.

Changes in Facies.

Lower Burindi Series.

The rhythmical deposition of the beds of tuff and mudstone throughout the series is indicative of oscillations in the relations of land and sea during Lower Burindi time. No marker horizons have been established for the series throughout the region though some have a local application; e.g., the oolitic limestone at Barrington (Voisey, 1940) has been useful. Although the series has not been studied in great detail, a few general observations have some point. Sussmilch (1935, p. 89) drew attention to the fact that a coarse crinoidal limestone has been found in many places near the base of the series while oolitic limestones characteristically occur near the top.

Except at Barrington, where conglomerates are present, the basal beds of the Lower Burindi Series have not been studied in the coastal areas. At Babbinboon, Carey (1937) discovered basal conglomerates conformably overlying the Barraba Series of the Devonian. Except for the limestones and occasional conglomerates, the remainder of the sequence consists of tuffs and grey and olive-green mudstones. The tuffs vary considerably in their lithology throughout the deposition area. So far no limestones have been found in the series in coastal areas of New South Wales north of the Manning River.

The probable position of the Lower Burindi strand-line was indicated on a map given by Carey and Browne (1938, p. 610) (Plate v, fig. 2A).

The Wallarobba Disturbance (Sussmilch and David, 1919) at the close of Lower Burindi time raised some parts of the area of marine sedimentation above sea-level.

Upper Burindi (= Lower Kuttung) Series.

As indicated by Carey and Browne (1938, p. 610), it is possible to separate an area of terrestrial deposition from one of marine deposition during Viséan time.

Further changes in the relations of land and sea can now be indicated as shown on the three maps (Plate v, figs. 2B, 2C and 2D). The presence of the *Lithostrotion* limestone at Babbinboon among terrestrial sediments makes it necessary to show these changes.

The Lower Burindi sequence passes upwards into the Lower Kuttung in the type-area of the Hunter River—it being difficult to draw a sharp boundary between the two (Osborne, 1922). The Wallarobba Conglomerate, taken as the basal unit, occurs as far north as Weistmantels and west of Bullah Delah but is not represented at Barrington where a lava flow has been taken as the lowest unit (Voisey, 1940). Tuffs and conglomerates form the basal beds of the Lower Kuttung Series to the west in the Currabubula district.

The terrestrial origin of these sediments forming the Basal Stage of the (Lower) Kuttung (Osborne, 1922) is demonstrated by the presence, in tuffs overlying the conglomerates in the Clarencetown and Currabubula areas, of well-preserved remains of *Lepidodendron, Ulodendron, Stigmaria* and *Pitys* (Osborne, 1922; Carey, 1937).

Towards the sea, fresh-water sediments merge into marine ones, and it is not always possible to divide the Carboniferous sequence into series corresponding exactly to those of the type area.

In the Gloucester area a littoral marine facies takes the place of the terrestrial one, though the sediments are somewhat similar in each case. A shelly fauna including the large Productid *Productus barringtonensis* has been found. Beyond this the sediments change to those of the Lower Burindi type as in the Mount George–Wingham area and along the coastal strip between the Manning and Karuah Rivers.

At Taree the *Lithostrotion* limestone was formed while the Gloucester beds seem to have still remained littoral in character. The seas extended far to the west to reach Babbinboon and Rocky Creek. Oolitic grits and conglomerates in the first-named locality indicate proximity to the shore-line there. Terrestrial conditions obtained in the Hunter Valley all through the Lower Kuttung.

The change back from marine to terrestrial conditions at Babbinboon following the marine transgression is indicative of an easterly retreat of the sea. Again, neither the Gloucester nor the Hunter district seems to have been affected.

The areas of terrestrial deposition during the Lower Kuttung are characterized by volcanic lavas of great variety (Osborne, 1922, etc.; Carey, 1937). Only in the Rocky Creek and Gloucester areas have lavas been found associated with a marine sequence of Viséan Age in New South Wales. It would seem, therefore, that the centres of volcanic activity ran parallel to the strand-line and were more or less restricted to the coastal strip.

Upper Kuttung.

Another major change in the relations of land and sea took place as a result of the Drummond Movement at the close of Viséan time. The sea retreated to the north-east and the strand-line moved to the north of the Macleay River. How far north cannot be determined as the deposits have been removed by erosion.

Terrestrial sedimentation in early Upper Kuttung time took place apparently in a number of isolated basins. Some areas, for example, the Mount George–Taree area may have remained dry land, since no rocks of this age have been found there.

The Main Glacial Beds which follow the Main Clastic Zone do not appear to have been deposited over much of the area between the Karuah and Manning Rivers, i.e., in the neighbourhood of the Gloucester Trough. This may well have been high land formed as a result of great outbursts of volcanic activity and the deposition of the Main Clastic Zone. It is noteworthy that sediments of the Lower Marine Series (Kamilaroi) are also absent from this area, unless the Gloucester Coal Measures are their terrestrial equivalents.

The glacial beds of the Hunter Valley are well known. They appear to be terrestrial in origin, while the particular interest of those north of the type-area mentioned above is that some of them at least are marine. It is possible that marine conditions prevailed there through the epoch, indicating a southern advance of the shore-line.

In the north-east portion of the State it is probable that marine conditions were maintained throughout Carboniferous time as indicated by the sediments of the Emu Creek Series (Voisey, 1936*b*, pp. 157–158).

Conclusion.

Our knowledge of the Carboniferous system in New South Wales is still far from complete, but sufficient is known to demonstrate the fact that there are represented beds laid down under a great variety of conditions. It has been possible to indicate roughly by means of palaeographical maps the principal facies during successive stages in the formation. These changes have led to difficulties of nomenclature since terrestrial and marine beds have been laid down synchronously, and the boundaries of the areas of deposition have been changed from time to time.

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EXPLANATION OF PLATE V.

Fig. 2A.—Lower Burindi. The areas occupied by land and sea during Tournaisian times have been taken from a map by Carey and Browne (1938).

Figure 2A is the key to place names which are indicated only by letters elsewhere. Other information appears as required and carries on for subsequent maps.

Fig. 2B.—Upper Burindi-Lower Kuttung. The Viséan beds are considered in three parts: 1, those below the *Lithostrotion* Limestone; 2, the horizon of the *Lithostrotion* Limestone and its equivalents; 3, those above the *Lithostrotion* Limestone.

Figures 2B, 2C and 2D show the distribution of land and sea and the area of terrestrial deposition in each case.

Fig. 2E.—Upper Kuttung-Main Clastic Zone. Within the dotted area were fresh-water lakes and thus a regression of the sea is indicated. The absence of sediments in the Taree-Wingham area suggests that this was dry land.

Fig. 2F.—Upper Kuttung-Main Glacial Zone. The Gloucester-Stroud area was probably an elevated block with some, at least, of the glacial beds to the north being laid down under marine conditions.

Fig. 2G.—Carboniferous Lava Flows. Proven Carboniferous lavas are restricted to the shaded area. They are mostly interbedded with terrestrial sediments.

Fig. 2H.—Kamilaroi-Lower Marine. This map has been included to demonstrate the relationship between Carboniferous deposition areas and those of the subsequent period.

Note the extension of the land area around Gloucester which was instrumental in preventing some of the characteristic Queensland fauna from migrating to the Hunter River Province.

The actual glacial beds are not continuous but the marine beds which follow are found through much of the area indicated.

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